US020475

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 547 674 A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **92203820.3**

(51) Int. Cl.5: **H05B 41/29**

(22) Date of filing: **09.12.92**

(30) Priority: **16.12.91 EP 91203294**

(43) Date of publication of application: **23.06.93 Bulletin 93/25**

(84) Designated Contracting States: **BE DE FR GB IT NL**

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(54) **Circuit arrangement for eliminating the bubble effect.**

(57) The invention relates to a circuit arrangement for operating a low-pressure mercury discharge lamp by means of a high-frequency current which consists of a DC component G and a high-frequency AC component W, comprising

- switching means I for generating the high-frequency AC component W from a supply voltage,
- asymmetry means II for rendering an amplitude A1 of the high-frequency AC component W in a first polarization direction and an amplitude A2 of the high-frequency AC component W in a second polarization direction unequal to one another, and
- DC means III for generating the DC component G.

According to the invention, the polarity of the DC component G coincides with the polarization direction of the greater of the two amplitudes A1 and A2. It is achieved by this that striations in a low-pressure mercury discharge lamp operated on the circuit arrangement can be rendered invisible over a wide range of powers consumed by the lamp.

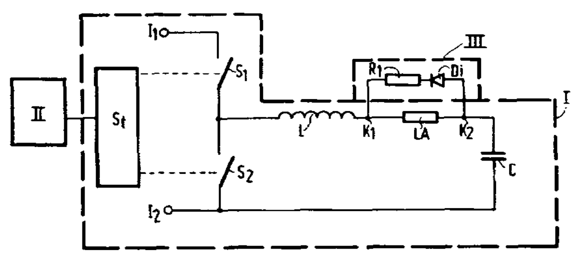

FIG.2

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The invention relates to a circuit arrangement for operating a low-pressure mercury discharge lamp by means of a high-frequency current which consists of a DC component G and a high-frequency AC component W, comprising

- switching means I for generating the high-frequency AC component W from a supply voltage,
- asymmetry means II for rendering an amplitude A1 of the high-frequency AC component W in a first polarization direction and an amplitude A2 of the high-frequency AC component W in a second polarization direction unequal to one another, and
- DC means III for generating the DC component G.

Such a circuit arrangement is known from International Patent Application WO 86/06572. Striations are formed in a low-pressure mercury discharge lamp (referred to hereinafter as the lamp) operated on the known circuit arrangement, i.e. alternating comparatively dark and comparatively light regions in the plasma of the lamp. The striations often move through the lamp. The direction in which and the velocity with which the striations move through the lamp depend both on the ratio between amplitude A1 and amplitude A2 and on the amplitude and polarity of the DC component G. This renders it possible to adjust the speed with which striations move through the lamp by using asymmetry means II and/or DC means III. The known circuit arrangement thus offers the possibility, for example, of making striations substantially stationary in the lamp, which may be desirable, for example, in lamps which are used for advertising purposes. A second possibility of the known circuit arrangement is to use the asymmetry means II and/or III for making the velocity of the striations so great that the human eye is substantially incapable of observing them any more. It seems as a result as if the brightness in the lamp is substantially uniform, and objects in the vicinity of the lamp are evenly illuminated. These two effects of the second possibility are desirable in the majority of practical applications of the lamp, i.e. that it is substantially always desirable to render striations in the lamp invisible. Factors which influence the occurrence of striations are *inter alia* the ambient temperature of the lamp, the power consumed by the lamp, and the composition of the lamp plasma. It has been found that it is not or substantially not possible under unfavourable conditions to render striations invisible through the exclusive use of asymmetry means II or DC means III. Since the known circuit arrangement is provided with both the asymmetry means II and the DC means III, it is possible in principle to influence the velocity with which striations move through the lamp more strongly than would be possible with a circuit arrangement which is provided only with means for generating a DC component of the lamp current or which is provided only with means for rendering an amplitude of a high-frequency alternating current through the lamp in a first polarization direction and an amplitude of the high-frequency alternating current in a second polarization direction unequal to one another. It was found, however, that the effect on the velocity with which the striations moved achieved by the asymmetry means II is in practice often opposed to the effect achieved by the DC means III. The result of this is that, in spite of the combined use of asymmetry means II and DC means III, it is hardly possible to render striations invisible, and the known circuit arrangement functions ineffectively.

The invention has for its object *inter alia* to provide a circuit arrangement with which it is possible to render striations in the lamp substantially entirely invisible under widely differing operating conditions.

According to the invention, this object is achieved in that the polarity of the DC component G coincides with the polarization direction of the greater of the two amplitudes A1 and A2 in a circuit arrangement of the kind mentioned in the opening paragraph.

It was found that in a circuit arrangement according to the invention the effect of the asymmetry means II on the velocity with which striations move through a lamp operated on the circuit arrangement and the effect of the DC means III on this velocity reinforce one another. This makes it possible to render striations invisible in low-pressure mercury discharge lamps of various types and under widely differing operating conditions.

In an advantageous embodiment of a circuit arrangement according to the invention, the switching means I comprise switching means for generating a substantially square-wave voltage with a duty cycle D from a DC voltage, asymmetry means II comprise means for rendering the duty cycle D unequal to 50%, and the circuit arrangement comprises in addition a load branch B which is coupled to the switching means I and which comprises a series circuit of capacitive means C and lamp connection terminals K1 and K2. Since the duty cycle D of the substantially square-wave voltage is not equal to 50%, the time interval in each high-frequency cycle of the AC component W during which the AC component W flows in the first polarization direction is unequal to the time interval during which the AC component W flows in the second polarization direction. At the same time, the presence of the capacitive means C renders the quantity of charge displaced by the AC component W in the first polarization direction substantially equal to the quantity of charge displaced by the

AC component W in the second polarization direction. These two conditions have the result that the amplitudes A1 and A2 of the AC component W have different values.

Another advantageous embodiment of the invention is characterized in that the DC means III comprise a branch which comprises a series circuit of an impedance and a unidirectional element and which shunts the low-pressure mercury discharge lamp. The impedance may be, for example, a resistor. Especially if the lamp voltage is comparatively low, this branch constitutes a comparatively simple and efficiently operating embodiment of the DC means III.

A further advantageous embodiment of a circuit arrangement according to the invention is characterized in that the circuit arrangement comprises capacitive means which are connected in series with the lamp and are shunted by a branch which comprises an impedance. In this advantageous embodiment, the impedance may also be, for example, a resistor. This embodiment of the DC means III is particularly advantageous when the lamp voltage is comparatively high.

Embodiments of the invention will be explained in more detail with reference to a drawing.

In the drawing, Fig. 1 shows a diagrammatic picture of an embodiment of a circuit arrangement according to the invention;

Fig. 2 shows the embodiment of Fig. 1 in more detail;

Fig. 3 shows a further embodiment of a circuit arrangement according to the invention; and

Fig. 4 shows parameters of various operating conditions of a low-pressure mercury discharge lamp operated on a circuit arrangement as shown in Fig. 2, whereby striations in the low-pressure mercury discharge lamp are substantially invisible.

In Fig. 1, I1 and I2 are input terminals suitable for connection to a supply voltage source. I are switching means for generating a high-frequency AC component W from the supply voltage source. Switching means I are provided with lamp connection terminals K1 and K2 to which a lamp La is connected. II are means for rendering an amplitude A1 of the high-frequency AC component W in a first polarization direction and an amplitude A2 of the high-frequency AC component W in a second polarization direction unequal to one another. Asymmetry means II are for this purpose coupled to switching means I. III are means for generating a DC component G. DC means III are for this purpose also coupled to switching means I.

The operation of the circuit arrangement shown in Fig. 1 is as follows.

When the input terminals I1 and I2 are connected to a supply voltage source, a high-frequency current consisting of the high-frequency AC component W and the DC component G will flow through the lamp La. The switching means I generate the high-frequency AC component W, whereas the DC means III generate the DC component G. Asymmetry means II render the amplitude A1 of the high-frequency AC component W in a first polarization direction unequal to the amplitude A2 of the high-frequency AC component W in the second polarization direction. The polarity of the DC component G is chosen to be equal to the polarization direction of the greater of the two amplitudes A1 and A2. This renders it possible to make striations invisible in lamps of differing types and over a comparatively wide range of powers consumed by the lamp.

In the circuit arrangements shown in Fig. 2 and Fig. 3, the switching means I are constructed as an incomplete half bridge comprising a series circuit of input terminal I1, switching elements S1 and S2, and input terminal I2. The incomplete half bridge in addition comprises a load branch which shunts the switching element S2 and comprises a series circuit of a coil L, lamp connection terminal K1, lamp La, lamp connection terminal K2, and capacitor C which in these embodiments forms the capacitive means C. Also part of the incomplete half bridge is the control circuit St which is coupled to the switching elements S1 and S2 for rendering the switching elements conducting and non-conducting with high frequency. Asymmetry means II are coupled to an input of the control circuit St. In the embodiment shown in Fig. 2, the DC means III are constructed as a series circuit of a diode Di and a resistor R which shunts the lamp La. In the embodiment shown in Fig. 3, the DC means III are constructed as a resistor R which shunts the capacitor C.

The operation of the circuit arrangement shown in Fig. 2 is as follows.

When input terminals I1 and I2 are connected to the positive and the negative pole of a DC voltage source, respectively, a high-frequency control signal generated by the control circuit St renders the two switching elements S1 and S2 alternately conducting and non-conducting with high frequency. As a result, a high-frequency, substantially square-wave voltage is present across the ends of the load branch. The duty cycle D of the high-frequency, substantially square-wave voltage is set for a value which is not equal to 50% by the asymmetry means II. A high-frequency alternating current flows through the load branch as a result of the high-frequency, substantially square-wave voltage. Since the duty cycle D of the high-frequency, substantially square-wave voltage is not equal to 50%, the amplitude of the alternating current in a first polarization direction is unequal to the am-

plitude of the alternating current in the second polarization direction. In addition, the diode Di only passes current in one polarization direction and is blocked in the other direction, so that the lamp current has a DC component G. To optimize the joint effect of asymmetry means II and DC means III on the visibility of striations, according to the invention, the duty cycle D is set for a value below 50% if, as shown in Fig. 2, the anode of diode Di is coupled to capacitor C and the cathode of diode Di is coupled to a junction point shared by the two switching elements. If, on the other hand, the anode of diode Di is coupled to a junction point shared by the two switching element S1 and S2 and the cathode of diode Di is coupled to capacitor C, the joint effect of the asymmetry means II and DC means III is at its optimum when the value of the duty cyle D is chosen to lie above 50%.

The operation of the circuit arrangement shown in Fig. 3 largely corresponds to that of the circuit arrangement shown in Fig. 2. The difference consists in that the DC component G of the current through the lamp La in this embodiment is realised by the resistor R2 which shunts the capacitor C. An optimization according to the invention of the joint effect of asymmetry means II and DC means III on the invisibility of striations in the lamp is achieved in this embodiment when the duty cycle D is chosen to be lower than 50%.

Fig. 4 shows the amplitude ILA-DC of the direct current through a low-pressure mercury discharge lamp required for rendering striations substantially invisible as a function of the duty cycle D of the substantially square-wave voltage, the low-pressure mercury discharge lamp being operated by means of a circuit arrangement as shown in Fig. 2. The amplitude ILA-DC is expressed in mA and the duty cycle D in percents. The low-pressure mercury discharge lamp contained krypton and its power rating was 32 W. The points in Fig. 4 were measured at an ambient temperature of approximately 295 K, while the low-pressure mercury discharge lamp burned in the non-dimmed state. It is evident that a direct current of approximately 4,5 mA is required for rendering striations substantially invisible for a value of the duty cycle D of 49% and 51%, provided the polarity of the direct current does not correspond to the polarization direction in which the AC component has its greater amplitude. However, if the polarity of the direct current corresponds to the polarization direction in which the AC component has its greater amplitude, a direct current of less than 1,5 mA will suffice. It can also be seen that the required direct currents are situated symmetrically relative to the point (D = 50%, ILA-DC = 0 mA).

Apart from the test results shown in Fig. 4, it was found to be possible to render striations invisible in the low-pressure mercury discharge lamp containing krypton over a range of powers consumed by the lamp from 10% to 100% of the rated power. When the duty cycle D was chosen between 43% and 57%, and the polarity of the direct current coincided with the polarization direction of the smaller of the two amplitudes A1 and A2, a direct current of approximately 14 mA was necessary to achieve this purpose. Such a high direct current gives rise to a comparatively high power dissipation and in addition to cataphoresis in the lamp. Such a high direct current is undesirable for these two reasons. When on the other hand the polarity of the direct current coincided with the polarization direction of the greater of the two amplitudes A1 and A2, it was found to be possible to render striations invisible at the same values of the duty cycle D and of the power consumed by the lamp by means of a direct current of no more than approximately 1,5 mA, so that power dissipation as a result of this direct current is comparatively low and cataphoresis does not occur in the lamp to any noticeable extent, so that the invisibility of striations is realised in an efficient manner.

Claims

1. A circuit arrangement for operating a low-pressure mercury discharge lamp by means of a high-frequency current which consists of a DC component G and a high-frequency AC component W, comprising
   - switching means I for generating the high-frequency AC component W from a supply voltage,
   - asymmetry means II for rendering an amplitude A1 of the high-frequency AC component W in a first polarization direction and an amplitude A2 of the high-frequency AC component W in a second polarization direction unequal to one another, and
   - DC means III for generating the DC component G,

   characterized in that the polarity of the DC component G coincides with the polarization direction of the greater of the two amplitudes A1 and A2.

2. A circuit arrangement as claimed in Claim 1, characterized in that the switching means I comprise switching means for generating a substantially square-wave voltage with a duty cycle D from a DC voltage, asymmetry means II comprise means for rendering the duty cycle D unequal to 50%, and the circuit arrangement comprises in addition a load branch B which is coupled to the switching means I and which

comprises a series circuit of capacitive means C and lamp connection terminals K1 and K2.

3. A circuit arrangement as claimed in Claim 1 or 2, characterized in that the DC means III comprise a branch which comprises a series circuit of an impedance and a unidirectional element and which shunts the low-pressure mercury discharge lamp.

4. A circuit arrangement as claimed in Claim 1 or 3, characterized in that the circuit arrangement comprises capacitive means which are connected in series with a low-pressure mercury discharge lamp operated on the circuit arrangement and are shunted by a branch which comprises an impedance.

5. A circuit arrangement as claimed in Claim 2, characterized in that the capacitive means C are shunted by a branch which comprises an impedance.

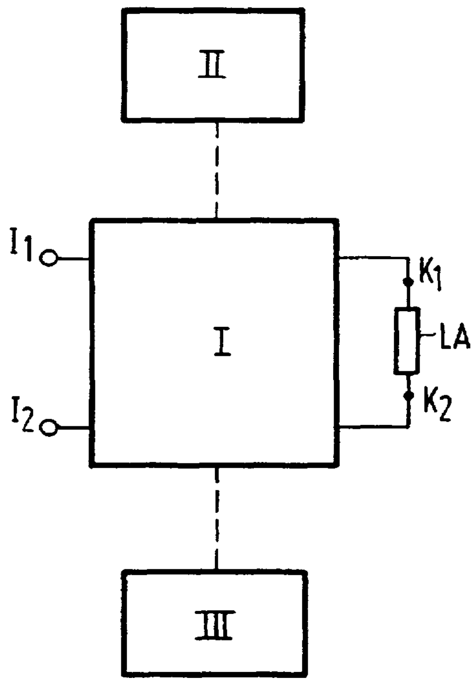


FIG.1

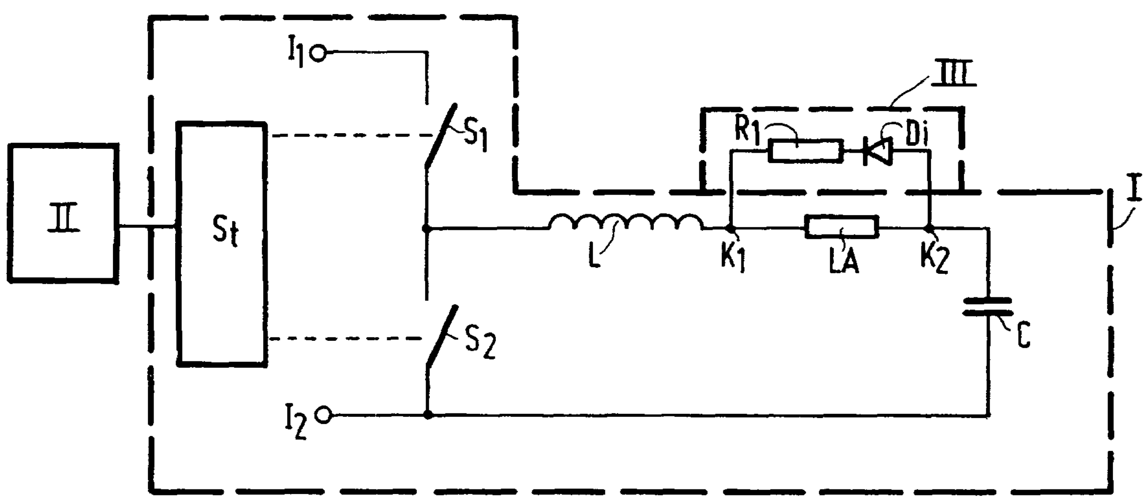


FIG.2

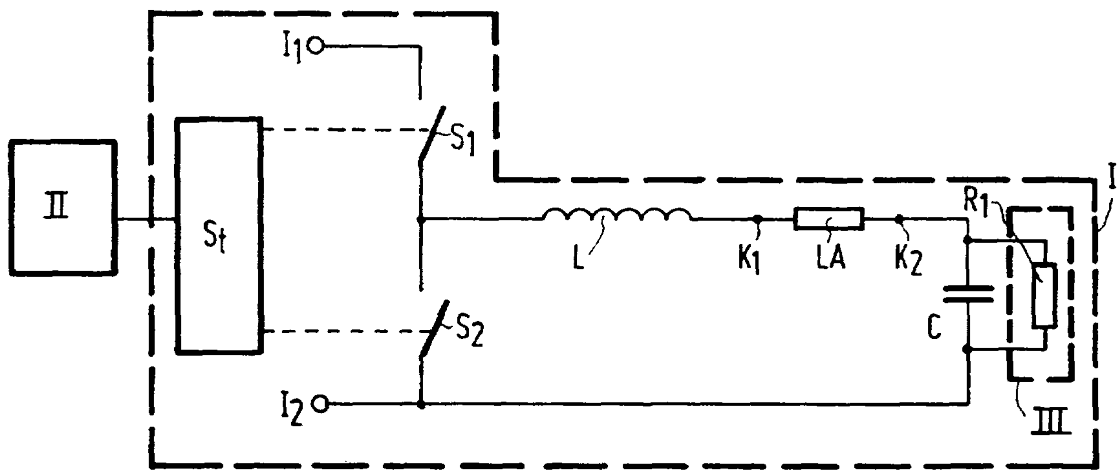
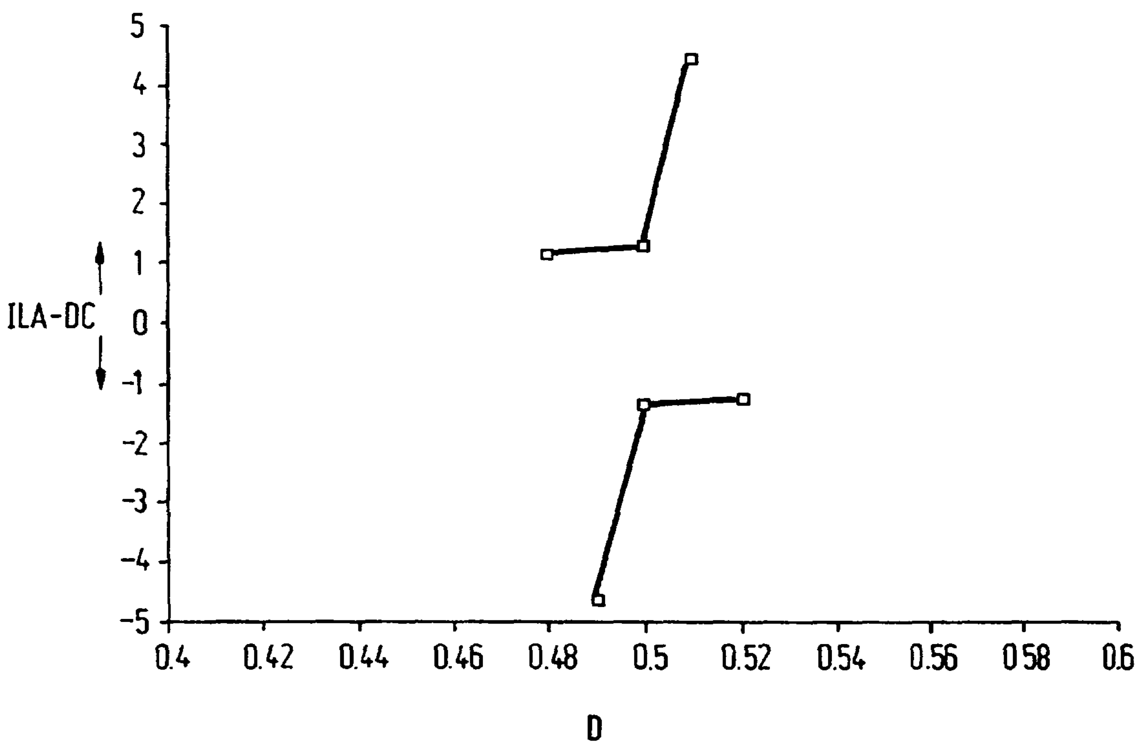

II
St
I1
S1
S2
I2
L
K1
LA
K2
R1
C
III
I

FIG. 3


ILA-DC
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4
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2
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-2
-3
-4
-5
0.4
0.42
0.44
0.46
0.48
0.5
0.52
0.54
0.56
0.58
0.6
D

FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 20 3820

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-5 001 386 (SULLIVAN) * column 2, line 39 - column 3, line 29 * * column 6, line 17 - column 6, line 31; figures 2,3 *	1,3-5	H05B41/29
A,D	WO-A-8 606 572 (HERRICK) * page 5, line 19 - page 8, line 6; figures 2,5,6 *	1,2,4,5	
A	GB-A-2 119 184 (SAIRANEN) * page 1, line 24 - page 2, line 27; figures 1-3 *	1,4,5	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 MARCH 1993	SPEISER P.

CATEGORY OF CITED DOCUMENTS

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